STUDY ON THE ROLE OF DOPPLER ULTRASOUND AND RESISTIVE INDEX IN OBSTRUCTIVE UROPATHY

Dissertation submitted in partial fulfillment of the requirements for the degree of

M.CH (GENITOURINARY SURGERY)

MADRAS MEDICAL COLLEGE

TAMIL NADU MGR MEDICAL UNIVERSITY

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CERTIFICATE

This is to certify that the dissertation entitled **Study on the role of Doppler ultrasonography and resistive index in obstructive uropathy**– done under our supervision and is the bonafide work of **Dr.PR.Saravanan**. It is submitted in partial fulfillment of the requirement for the M.Ch. (Genitourinary surgery) examination.

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STUDY ON THE ROLE OF DOPPLER ULTRASONOGRAPHY

& RESISTIVE INDEX IN OBSTRUCTIVE UROPATHY

CONTENTS:

AIM:

The role of resistive index in the diagnosis of acute renal colic and obstructive uropathy is yet to be clearly defined inspite of a plethora of literature.

The following are the aims of this study:

- the primary aim is to determine whether the resistive index is sensitive and specific in diagnosing acute renal colic.
- To determine whether resistive index measurements are affected by age and sex
- To delineate the influence of site of obstruction on the resistive index measurements
- To determine the extent of variation of resistive index with the duration of obstruction
- To determine the role of inter-renal resistive index difference in diagnosing acute renal colic

MATERIAL AND METHODS:

The study was conducted on patients who attended the outpatient department of MADRAS MEDICAL COLLEGE and GOVERNMENT GENERAL HOSPITAL during the period Aug 2003 to JULY 2005

The study included 36 patients (30 male and 6 female, mean age range) with 72 kidneys, who presented with unilateral loin pain suspected of being renal colic.

Immediately on presentation all patients were prospectively evaluated with renal ultrasonography(US) followed by intravenous urography (IVU).US studies were carried out during the attack of loin pain in all patients and before giving any medications in most. US examination included real-time imaging and intrarenal Doppler Ultrasound (DU), performed using ALOKA 2000 (ALOKA SCEINTIFIC, JAPAN) using a transducer frequency of 3.5 m

Hz. The degree of pyelocaliectasis was assessed in each kidney on the grey scale images. Pelvicalyceal obstruction was graded as absent, mild, moderate and marked. At least five Doppler spectra were obtained from more than three regions in each kidney. Doppler signals were obtained from the arcuate arteries at the corticomedullary junction, interlobar arteries along the border of medullary pyramids or both. The Doppler waveforms were made using the lowest pulse repetition frequency possible without aliasing. This maximized the size of Doppler spectrum and decreased the percentage errors of measurement .in addition the lowest possible wall filter for each ultrasound scanner was used. The Doppler sample width was set at 3-5 mm. The resistive index was calculated using the formula:

$$RI = \frac{\text{peak systolic velocity} - \text{end diastolic velocity} /}{\text{peak systolic velocity}}$$

Differential resistive index=resistive index in corresponding kidney –resistive index in normal kidney.

RI ratio =resistive index in corresponding kidney/RI in normal kidney

IVU was interpreted as negative with a normal reno-ureteric unit and positive with hydroureter proximal to the stone, with or without delayed pelvicaliceal filling with contrast medium. I and DIFF.RI were considered positive with values of >0.70 and >0. 06 respectively.

The IVU results were considered gold standard with which DU findings were compared. The site of obstruction as diagnosed with IVU was classified as proximal, mid- and distal ureter. The duration of obstruction was classified into <24 hours, 24-48 hours and >48 hours.

The sensitivity and specificity of DU values for the diagnosis of acute unilateral ureteric obstruction were calculated. Differences were assessed using the ANOVA test (analysis of variables) and student‘s t tailed test as appropriate.

INTRODUCTION :

Despite recent advances in the field of Urological Ultrasonography certain diseases of Upper Urinary Tract such as obstructive dilatation remain elusive to conventional imaging techniques.

While conventional US is a sensitive method for detecting Upper Urinary Tract dilatation with upto 98% sensitivity reported in earlier studies (1) it lacks the ability to provide significant physiological data on renal status and, hence cannot specifically assess the cause of obstructive dilatation. This lack is especially relevant in the paediatric age group in which the obstruction, and when proper management depends on detecting the underlying cause of dilatation. However with the advent of DU new insight into the physiology of the kidney has emerged, enabling the detecting of subtle renal blood flow changes associated with various pathophysiological conditions. These changes may be semiquantified by calculating the Intrarenal Vascular Resistive Index.

REVIEW OF LITERATURE :

US-SENSITIVITY AND PROBLEMS IN DIAGNOSING OBSTRUCTION :

US is a sensitive detector of collecting system dilatation in patients with chronic obstruction and normal or impaired renal function(1-3). To achieve high sensitivity in the setting were obstruction is suspected, any visualization of the collecting system must be considered and evaluated further (4).

Causes of a false positive diagnosis (5) include :

1) Visualization of a normal pelvicalyceal system (5) when there are anatomical variants such as extra renal pelvis, when the bladder is distended or under conditions of diuresis.
2) Visualization of a dilated but unobstructed system when there is VUR, a distensible system after previous obstruction or infection, dilated calyces (e.g. in papillary necrosis or reflux nephropathy) or during normal pregnancy (6).
3) Central renal fluid collections other than the pelvicalyceal system, including normal vessels (particularly veins (7) renal artery aneurysm and peripelvic cysts (8) .

Conversely US imaging may miss the diagnosis of obstruction in a variety of situations (5).

1) Mild dilatation may be overlooked are considered clinically insignificant

2) Minority of patients with obstructive renal failure may show no pelvicalyceal dilatation (upto 5%) (9 – 12). The reason for this are unclear; in patients it may relate to dehydration or to decompression of the pelvicalyceal system by rupture of a calyceal fornix.

3) Undilated obstruction in the contralateral kidney should be suspected when a patient has renal failure, known retroperitoneal malignancy and dilatation of pelvicalyceal system in one kidney (12). Pelvicalyceal dilatation may be missed if the system is filled with blood clot, calculus, tumour or pus. A plain film should always be obtained to check for renal calculi. Large stones may be missed.

4) Intermittent Ureteric obstruction particularly caused by Ureteric Calculi may also lead to failure to visualize the collecting system with US.

FUNCTIONAL DIAGNOSIS OF OBSTRUCTION USING DOPPLER :

The use of Doppler US to improve the anatomical diagnosis of obstruction by showing whether central renal fluid collections represent the pelvicalyeal system are results has already been described.

Over recent years there has been a profusion of studies evaluating the role of Doppler US for providing functional evidence of obstruction, principally by measuring the resistive index but also by assessing the ureteric jets.

Renal blood flow changes in obstruction ;

Acute renal obstruction results in a complex sequence of changes in renal blood flow and ureteric pressure (13).

First 2 hours - blood flow increases because of afferent arteriole vasodilatation and the ureteric pressure increases.

2 to 6 hours - renal blood flow decreases secondary to vasoconstriction of the efferent arterioles and ureteric pressure remains elevated.

6 to 18 hours - blood flow remains reduced because of vasoconstriction of the afferent arterioles and the ureteric pressure decreases.

ith bilateral obstruction the initial pattern of blood flow change is slightly different, but the resultant decrease in the renal blood flow by 24 hours is similar to that of unilateral ureteric obstruction.

Renal blood flow can be assessed by Doppler US using the resistive index, obtained by subtracting the peak diastolic velocity (or frequency shift) from the peak systolic velocity (or frequency shift) and dividing the result by the peak systolic velocity. Normal renal arterial flow has a low resistant pattern with flow maintained through the diastole .

During extreme elevations of renal vascular resistance diastolic flow may be non detectable or may even show retrograde propagation (14). Therefore, Doppler ability to characterize altered wave forms in response to elevations of renal vascular systems may be used to calculate the resistive index and may possibly be used to discriminate among various pathophysiological conditions of the kidney (15,16).

Doppler wave form studies are non-invasive, painless, readily available, and relatively easy to perform and learn. In addition, DU obviates the need for ionizing radiation and the intravenous contrast material administration in

situations in which there may be undesirable, such as pregnancy, allergy and renal insufficiency.

The detection of ureteral jet , or the flow of urine from the ureter into the bladder , effectively excludes obstruction.

Evaluation is performed in the transverse plane at the level of the trigone of the bladder. The bladder should be moderately filled and the patient should be hydrated. With the aid of colour Doppler , the ureteral jet is seen streaking from the ureteric orifice at the trigone diagonally into the bladder, crossing toward the contralateral side. The use of colour Doppler of ureteral jets was studied by Bude et al. an abnormal jet was described as the nonvisualization of the ureteral jet or the low level continuous flow from the symptomatic side. A normal ureteral jet was seen as periodic jets. The absence of ureteral jets is presumed due to obstruction of the ureter resulting in nom flow of urine into the bladder. Continuous low flow likely is caused by increased pressure in the obstructed ureter, permitting flow beyond the obstruction , but with ineffective peristalsis.

The addition of evaluation of ureteral jets further can improve the specificity of renal sonography in evaluation of acute renal obstruction,

further reducing the false positive rate of gray- scale ultrasound based solely on the appearance of hydronephrosis.

CLINICAL APPLICATIONS OF RESISTIVE INDEX :

The resistive index is physiological parameters reflecting the degree of renal vascular resistance. Therefore it is potentially applicable for detecting kidney disease associated with increase or decreased resistance of the intrarenal vasculature. Currently resistive index measurements are advocated for evaluating :

1) Dilated upper urinary tracts
2) Obstructive Uropathy
3) Allograft rejection
4) Pediatric Urological anomalies
5) Renal artery stenosis
6) Haemolytic Uremic syndrome
7) Acute Tubular Necrosis.

TECHNIQUE :

Reliable resistive index measurements depend on measuring proper techniques performed by experienced Sonographers. The majority of published studies have described the use of 3,3.5 or 5 MHz. transducers with Doppler sample volume of 2-5mm (18,19).

Doppler signals are obtained from arcuate arteries at the corticular medullary junction and interlobar arteries along the border of medullary pyramids. Studies have shown that resistive index measurements at these sites are identical (19) and technically easy to perform, thus improving reproducibility (20,21). In addition most renal pathological processes produce renal resistance alterations in these vessels (22 -24). These may be identified by colour flow mapping.

A Doppler spectrum is considered abnormal when 3 to 5 similar appearing consecutive wave forms are obtained.

Importantly some pathological processes are patchy involving only certain parts of the kidney. Therefore average multiple resistive index values from different locations of kidney and obtaining a mean value has been shown to produce a more reliable and reproducible parameter (25).

The practical implications of sampling a particular parenchymal region within a kidney or particular side in the healthy population have also been addressed in several studies which have provided no evidence to suggest a statistical significant relationship of the resistive index in normal healthy individuals (25-27). Although Keogan et al noted no significant effect attributable to sampling a particular parenchymal kidney region they reported the kidney status may be substantially represented when only one or two resistive index measurements are made (28). Thus they advocated averaging 3 to 5 readings from different sites especially in older adults since the probability of spurious readings exceeds with increasing age.

Palmer and Disandro showed that averaging multiple resistive index readings markedly decreased the standard deviation of the final result and hence increase the precision of the resultant resistive index measurement.

Optimal calibration of the settings on the Ultrasound device is tantamount to reliable readings, including setting the lowest possible machine valve filter to detect the low velocities typical of intrarenal arteries. Of even greater importance is the use of smallest possible frequency range without aliasing (artifacts caused by blood flow velocities exceeding an upper limit defined by

the frequency rate of the Doppler unit). This maneuver maximizes the deflection of the Doppler spectrum from baseline and fills as much of the scale as possible. This simple adjustment increases accuracy by producing a large spectrum, minimizing the relative error of measurement when positioning the cursor or placing the calipers (29).

Actual resistive index calculations may be done using the integrated software of the ultrasound unit or by hand measurements of hard copy using calipers.

US is performed to the patients in supine or in the lateral recumbent position, allowing kidney visualization via the anterior or lateral translumbar approach. Most DU examinations may be completed in 10-20mts with the patient's movement and inability to suspend respiration as the main reasons cited in most studies as the cause of more protracted examinations (18,30).

For consistent results and with the aim of minimizing physiological variability it has been advocated that patients should be examined after 30mts of rest while supine and under similar ambient conditions. Physiological investigations that have demonstrated post prandial renal blood flow changes

may even warrant that examinations should be performed in the fasting state.(31,32).

RESISTIVE INDEX NORMAL RANGE AND VARIABILITY :

A pre-requisite for the diagnostic use of resistive index measurements is the definition of a normal range, variability of measurements and upper limit of the normal RI.

In 1989 Platt et al established a nomogram and resistive index cut off value that would set the basis for many of the following studies in this field (25). In their series of 109 non dilated non diseased normal adult kidneys the resistive index range was 0.50 to 0.67 (mean + / - SD 0.58 + or - 0.05). The upper limit of normal was defined by analysing a subgroup of 70 dilated kidneys. Of which 38 subsequently proved to be obstructed, using conventional methods such as Percutaneous Nephrostomy, RGP, IVU, or contrast CT. This analysis resulted in resistive index of 0.70 as the optimal cut of value of obstructed versus non obstructed hydronephrosis yielding a sensitivity 92% , 88% specificity and 90% overall accuracy. This cut of value has since been universally adopted as a marker of abnormally elevated resistance in the renal vasculature and also has been applied to several other

renal pathophysiological conditions regardless of age or species. This obstructions of a universal nomogram and a fixed cut of value has probably let to some of the contradictions and controversies observed while reviewing the literature.

It is now generally accreted that the resistive index is an age dependent parameter (26,33-35). Bude et. al. showed that infants younger than 6 months had significantly higher mean resistive index values than adults and in this age group the probability of an index greater than 0.70 was as high as 57% . Values also tended to decrease with increasing age approaching adult levels at about year4 of life, and by age 7 years values were similar to those in adults (25).These findings are consistent with results of experimental studies showing that new born animals have renal vascular resistance levels exceeding those of adults (31,32).Human infants have also been shown to have significantly higher plasma concentrations and a higher activity of renin, which may explain the high renal vascular resistance levels in this age group.Consequently applying adult criteria to children especially to infants , may result in inconsistencies since the mean resistive index in infants is higher than that in the expected adult population(33). Adult criteria may be applied to children from the beginning of

year 4 of life with a probability of a mean resistive index of >0.70 as low as 2 % in healthy children 4 – 7 years old(33).

The aging kidney has also emerged as an important co variable influencing the resistive index. values in patients older than 60 years old tend to be higher than those in younger adults (36).

Platt et.al have suggested that this finding may be the result of true renal dysfunction in senescent kidneys and not merely the result of spurious variation or variability in the resistive index with age , a suggestion that builds on the fact that elevated values in patients older than 60 years old have correlated with compromised creatinine clearance.

Gill et al (28) observed that the average resistive index increases by 0.002 / year. This increase may be due to anatomical and functional changes in the renal vasculature with increasing age which decrease blood flow by 10 % year . Thus resistive index measurement s in subjects of age < 4years and > 60 years should be interpreted with some degree of caution.

THE RESISTIVE INDEX AND OBSTRUCTED UPPER URINARY TRACT:

Obstructive uropathy is usually associated with dilatation of the upper urinary tract .However not all dilatation is obstructive in nature . The differentiation in obstructed and non obstructed is crucial when contemplating treatment particularly in children in whom needless surgery may be avoided .

Grey – scale US and IVU are sensitive detectors of pyelocaliectasis but further elaboration on etiology cannot always be made on such investigations(37). Here DU may have an important role as an adjunctive conventional US.

Functionally significant obstruction of the upper urinary tract leads to a cascade of intrarenal cellular events that result in locally acting vasoactive factors of which thrombaxane A2, angiotensin 2, endothelin , nitric oxide seem to be important. This series of events and the production of vasoactive mediators lead to increased renal vascular resistance(22,38).This increase may be detected indirectly as an increase in the resistive index of the affected kidney(15,25).

RI measurement were compared with diuretic scintigraphy in children with hydroneprosis . The sensitivity and specificity of DU was found to be

100% and 87% when the value of > 0.70 was taken as abnormal. Resistive index also significantly correlates with T half of diuretic renogram. . In another study the sensitivity and specificity was 57% and 93%(36). However when the obstruction was graded into mild, moderate and severe the sensitivity of resistive index increased dramatically to 93%, suggesting the fact that mild and partial obstruction may not affect the renal blood flow much. In partially obstructed systems when the resistive index values are found to be normal the urinary flow rates and subsequently the intrarenal pressure can be increased by injecting diuretics. Diuretic enhanced measurement of resistive index have been found to be significant of obstruction in several studies (39-41).

INTER-RENAL RESISTIVE INDEX DIFFERENCES:

In cases with unilateral obstruction if the resistive index of the normal kidney is taken as the baseline value , then elevations attributable to obstruction would be detected even before the index reached the threshold value of > 0.70.

Differential resistive index=resistive index of obstructed kidney –resistive index of normal kidney

Ri ratio =resistive index of obstructed kidney /resistive index of normal kidney

Under normal conditions differential resistive index is < 0.08 to 0.1 and the resistive index ratio is < 1.10. it has been demonstrated in a number of studies that differential resistive index increases the sensitivity and specificity of resistive index. It also enables the detection of obstruction in kidneys with bilaterally elevated baseline resistive index values , as in medical renal disease or when the index has not reached the value of 0.070.
Therefore measurement of resistive index in both kidneys improves the sensitivity and specificity.

DIURETIC DOPPLER ULTRASOUND :

This is a modification of conventional DU that exploits the physiological responses of obstructed and nonobstructed kidneys to diuretic stimulation. It has been documented that furosemide provocation leads to significant increase in the resistive index of obstructed kidneys but not in nonobstructed dilated kidneys(42-45).

Diuretic DU is especially applicable to children < 4 years and neonates in whom a single cutoff value of > 0.70 is less specific. In Shokeir et. al. study using diuretic enhanced DU he achieved a sensitivity and specificity of 100% and 94% respectively. In these studies diuretic renography was used as a gold standard to confirm obstruction(33,45).

The strongest predictors of obstruction in children were differential resistive index and the difference between pre-diuretic and post-diuretic resistive index(Garcia Pena et.al).

DOPPLER US AS FOLLOW UP TOOL :

Doppler US can be used as a follow up investigation in the following situations :

- following reconstructive surgery such as pyeloplasty
- after placing stent or nephrostomy tube for relief of obstruction

  the role of resistive index in this situation has been elucidated in various studies (46,47). However the time duration by which the resistive index values return to normal after release of obstruction is not clearly

established. This may depend on factors relating to healing process such as postoperative edema. Similarly the interval of time needed for resistive index to increase to significant levels after development of re – obstruction is also not well defined. Nevertheless , DU has been recommended as a follow up tool , particularly in pediatric age group for postoperative follow-up as it is non- invasive.

Predicting renal function recoverability in cases of chronic obstruction has also been suggested as a potential use of DU. Shokeir et.al. reported that the reversal of previously elevated resistive index was a likely indicator of kidney recoverability(47). Clinically this result was achieved by monitoring the resistive index of a chronically obstructed kidney before and after release of obstruction (PCN).

IS RESISTIVE INDEX USEFUL FOR EVALUATING ACUTE OBSTRUCTIVE UROPATHY ?

The role of DU in acute renal obstruction has been much debated. The sensitivity and specificity of varies considerably with various studies. The first study was done by Platt etal in 1989.He reported a sensitivity

and specificity of 87% and 100% respectively for RI(48). Similar views were reported by Shokeir et al and Miletic et al. These studies also reported a sensitivity of 88% and 89% respectively. The specificity was 96% and 92%. But this early enthusiaism was dampened by two independent studies by Tublin et al and Deyoe et al wherein the sensitivity dropped to 30% and 37% respectively(49,51). Perhaps more importantly they also reported that the addition of DU did not improve the overall sensitivity of conventional US for diagnosing obstruction. Older et al also reported similar results. Eventhough there was a significant difference in the resistive index values in obstructed and non-obstructed(52) the sensitivity and specificity was too low to recommend resistive index for routine use.

The reasons for the discrepancy among various studies are not clear. Probably this may be due to :

- technique of measurement of RI
- lack of gold standard against which the resistive index could be compared. Different studies have used different investigations as gold standard.

The results are also influenced by the following factors:

- intermittent obstruction and partial obstruction have also been included in some studies. These cases have been associated with normal resistive index values.
- Pyelosinus extravasation is seen in 10-20% of acutely obstructed kidneys. Platt et al have argued that pyelosinus rupture leads to decompression of the pelvicalyceal system so that true obstruction is no longer present. The value of resistive index is questionable in the presence of perirenal or periureteral fluid(48,54,55).
- The functional severity of obstruction affects the degree of elevation of resistive index ;low grade obstruction causes less increase in resistive index(35,54).
- The degree of hydration of the patient affect the resistive index with higher values obtained when patient is undergoing a diuresis (56).
- The effects of clinical management are also important : treatment of pain with NSAIDs has shown to decrease resistive index probably due to the vasodilatory effect of the analgesics which are inhibitors of prostaglandin secretion

- The temporal relation of onset of obstruction and resistive index measurement has been greatly debated. During the first 6 hours of obstruction there is vasodilatation and hence resistive index measurement during the first 6 hours is likely to provide false-negative results.
- The accurate measurement if resistive index is technically demanding (52).

OTHER FACTORS AFFECTING resistive index:

1. Nephrological causes : Renal medical disease is probably the most important factor leading to the elevation of ri, especially in diseases affecting the vascular or tubulointerstitial compartments of the kidney such as acute tubular necrosis,interstitial nehphritis and various form of vasculitis(19,30).Therefore it may be difficult to diagnose unilateral obstruction in patients with a known renal medical condition. Due measurements with the calculation of differential resistive index or diuretic enhancement may still provide useful information.The finding of a normal resistive index in this setting may also help to argue against obstruction(27).

2. Diabetic nephropathy: in early stages of diabetic nephropathy the resistive index is reduced due to decreased vascular resistance. The index is particularly elevated in established diabetes.
3. Extra renal factors:
    a) blood pressure – increase in pulse pressure (difference between systolic and diastolic pressures) increases the resistive index(48).
    b) Heart rate: increasing heart rate causes decrease in the resistive index probably due to decrease in the cardiac output.
    c) Hydration status: dehydration , exsanguinations reduce the diastolic pressure thereby falsely increase the resistive index value.
    d) Compression : internal compression due to perirenal hematoma or any other space occupying lesion or external compression caused by the ultrasound probe itself can cause a false elevation of the RI.

In view of these many difficulties the current consensus is that measuring resistive index is unlikely to replace the anatomical imaging methods (urography,and more recently spiral unenhanced ct.(51). Interestingly this is even the view of some of strongest proponents of resistive index(65). The resistive index particularly the intrarenal resistive index should be used in

situations where US is chosen as the first imaging method in suspected ureteric colic e.g.

- Pregnancy-in unobstructed hydronephrosis of pregnancy resistive index values are normal (65) and an elevated resistive index, particularly if there is a significant interrenal resistive index difference, suggests ureteric obstruction.
- contrast allergy
- children
- as a follow up after reconstructive procedures such as pyeloplasty

RESULTS :

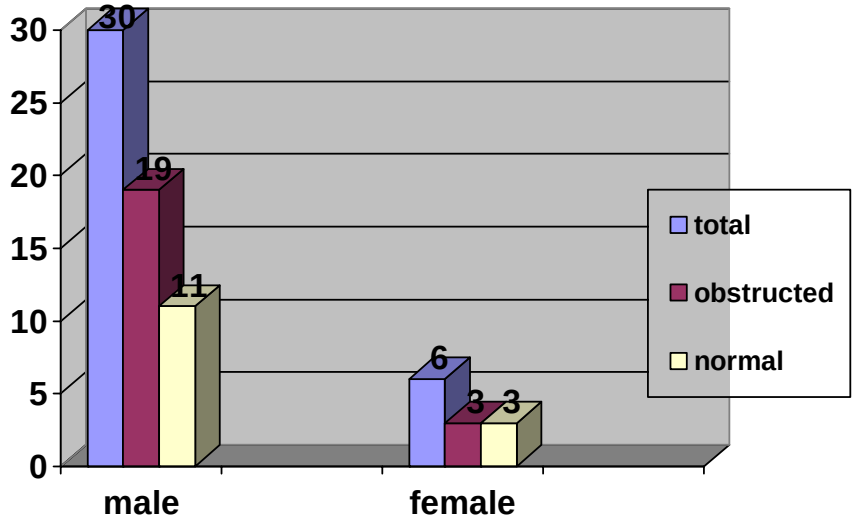
RESULTS & OBSERVATIONS :

In all use included 36 patients in our study. Of these patients predominant were males constituting 30 in males and 6 were females. The patients were in the age group of around twenty to fifty years (Range – Median age).

Total no. Of patients = 36

Male - 30

Female - 6



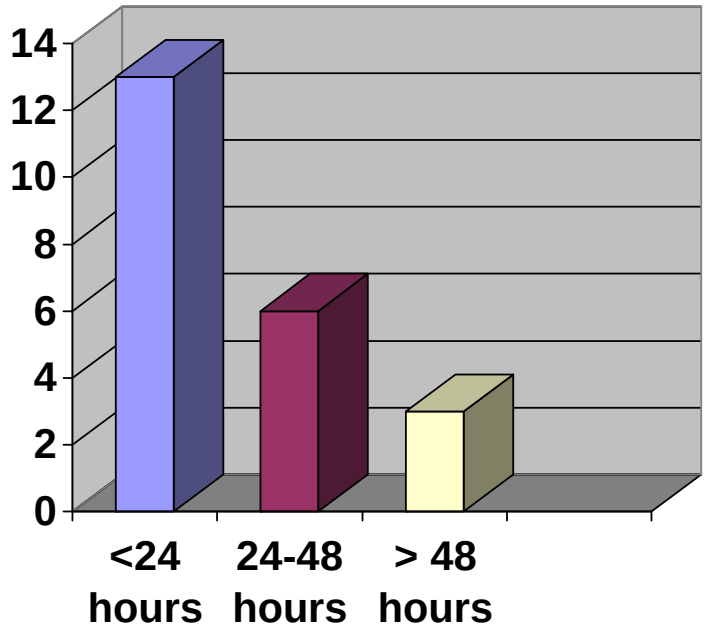
All these patients presented to our outpatient department with acute onset loin pain of duration less than four days. The duration of pain was further stratified into three categories :-

1. ------ duration < 24 hours
2. ------- duration 24 -48 hours
3. -------- duration > 48 hours

Around 13 patients with significant obstruction in IVU had attended the outpatient department with pain less than 24 hours duration. Six patients had pain for 1-2 days before attending the outpatient clinic , whereas the remaining 3 patients with obstructed system presented late after 2 days but before 4 days.

duration of pain :

< 24 hours	-	13
24- 48 hours	-	6
>48 hours	-	3

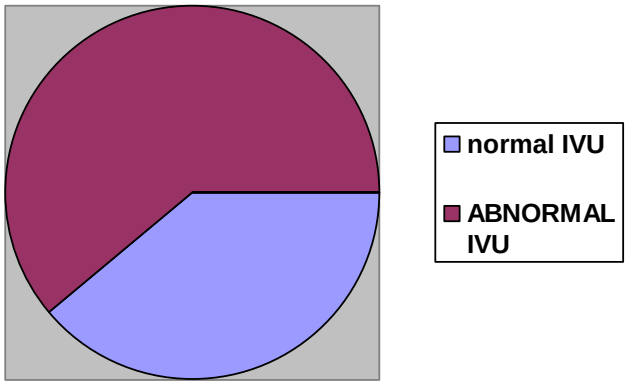


No patient presented to us with 6 hours of onset of pain

Results of IVU :

NORMAL STUDY ---- 14

OBSTRUCTION ---- 22

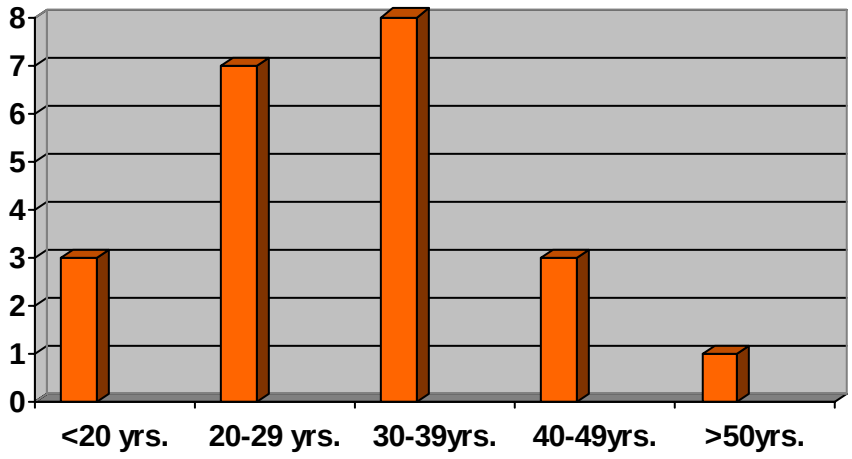


Cause of pain in patients with normal IVU :

1)myositis -	5
2) appendicitis -	3
3)colitis -	2
4) biliary colic -	1
5)non specific abdominal pain	5

age grouping of patients with obstructed kidneys:

< 20 years	-	3
20- 29 years	-	7
30-39 years	-	8
40-49 years	-	3
>50 years	-	1

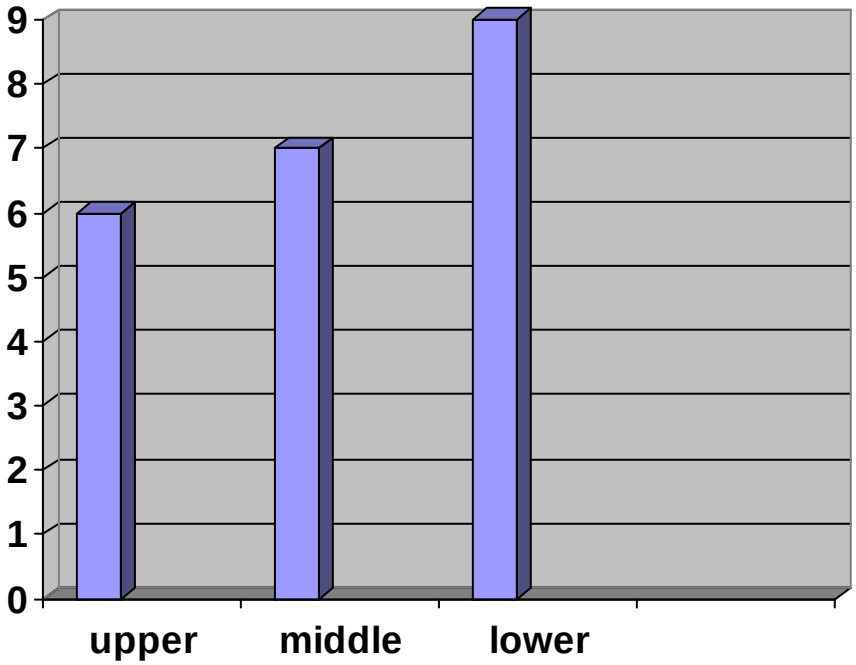


site of obstruction :

upper ureter - 6

middle ureter - 7

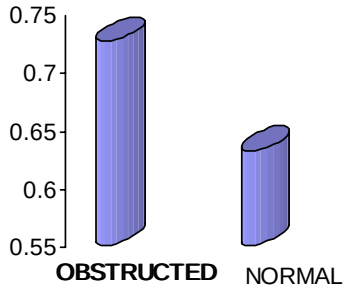
lower ureter - 9



MEAN RESISTIVE INDEX IN 22 OBSTRUCTED KIDNEYS – 0.7263

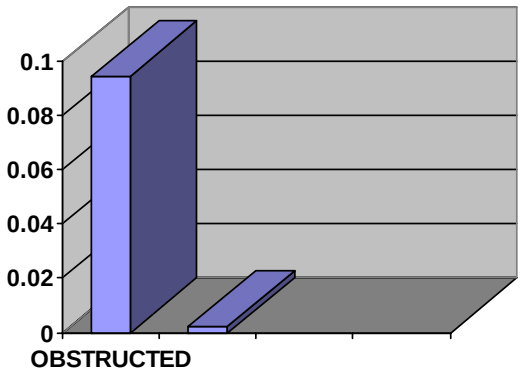
(0.05)

MEAN resistive indexIN NORMAL 50 KIDNEYS- 0.6390 (0.05)



MEAN DIFFERENTIAL resistive index IN OBSTRUCTED CASES : 0.0922 (0.05)

MEAN DIFFERENTIAL resistive index IN NORMAL PERSONS: 0.002(0.05)



SENSITIVITY AND SPECIFICITY OF RESISTIVE INDEX:		IVU RESULTS	
		POSITIVE	NEGATIVE
DU RESULTS	POSITIVE	19	4
	NEGATIVE	3	46

SENSITIVITY AND SPECIFICITY OF DIFFERENTIAL RI:		IVU RESULTS	
		POSITIVE	NEGATIVE
DU RESULTS	POSITIVE	20	2
	NEGATIVE	2	12

SENSITIVITY OF RI: 86%

SPECIFICITY OF RI: 92%

SENSITIVITY OF DIFF.RI: 90%

SPECIFICITYOF DIFF RI: 86%

DISCUSSION :

Beginning from Platt et al's pioneer study in1989, there are around eight studies in literature, regarding the value of resistive index in diagnosing & managing acute renal obstruction. The latest study conducted by Corderica et al in 2005.

The number of patients taken up in these studies vary from 10 (Platt et al) to 100 (Corderica et al).

The range of age in our series was 18 – 53 (mean 32.4), whereas in other series the age range is given below in table no. 1

Table no. 1

Series	Age range	Mean
Platt et al 1989	18 – 89	34.2
Shokeir et al 1999	18 – 70	37.8
Pepe et al 2005	22 – 67	35.6
Our series	18 – 53	32.4

In our series 36 patients were subjected to DU evaluation of whom 22 had obstruction documented by IVU.

The cut off value of resistive index was 0.70 in most of these series. Miletic et al considered 0.69 as the cutoff value whereas in Opdanekker' series it was 0.68.

Regarding inter-renal difference in resistive index also called as diferential resistive index the commonly followed cutoff values were 0.1 and 0.06.In our study we took 0.06 as the cut off value as in that of Shokeir et al , Miletic et al, and Opdanekker et al. Therefore similar to Shokeir`s study in our series the cutoff values of resistive index and differential resistive index were 0.70 and 0.06 respectively.

The final diagnosis or the reference investigation with which the resistive index measurements are compared are IVU, IVU & RGP, IVU RGP &AGP, Noncontrast helical CT . In the most recent study done by Corderica et al US , DU, NCCT was used

The following table (no.2) lists the details of methodology used in previous studies

References	No. of patients	Cut off values		Final diagnosis made
		Ri	Differential resistive index	
Platt et al	23	0.70	-	IVU
Shokeir et al	68	0.70	0.1	IVU
Miletic et al	54	0.69	0.06	IVU
Opdanekker et al	23	0.68	0.06	IVU,RGP& AGP
Tublin et al	19	0.70	0.1	IVU &RGP
Deyoe et al	10	0.70	0.1	IVU
Older et al	19	0.70	0.1	IVU
Pepe et al	100	0.70	0.1	IVU &NCCT
Our series	22	0.70	0.06	IVU

The sensitivity and specificity of resistive index in previous studies range from 30% to 94% and 79 to 100 %. In our study the sensitivity and specificity was 86% and 92% and this is in line with those of Platt et al , Shokeir et al , Miletic et al and Pepe et al

	Resistive index		Differential resistive index	
References	Sensitivity	Specificity	Sensitivity	Specificity
Platt	87%	100%	91%	N.A
Shokeir	77%	83%	88%	98%
Miletic	94%	90%	N.A	N.A
Opdanekker	83%	100%	N.A	N.A
Tublin et al	37%	84%	37%	100%
Deyoe et al	30%	100%	N.A	N.A
Older et al	42%	N.A	N.A	N.A
Pepe	98%	100%	N.A	N.A
Our series	86%	92%	90%	86%

The mean resistive index values in obstructed kidney and normal kidneys are given below :

References	Mean resistive index in obstructed kidneys	Mean resistive index in normal Kidneys	P value
Platt- 1989	0.726	0.64	<0.001
Shokeir -1999	0.73	0.634	<0.001
Miletic	0.72	0.64	<0.001
Platt - 1993	0.77	0.60	<0.001
Gottlieb et al	0.75	0.58	<0.005
Geavlette	0.74	0.62	<0.001
Pepe – 2005	0.74	0.65	<0.001
Our series	0.736	0.634	<0.001

The mean values of resistive index between previous studies and our's appear similar.

As in the study conducted by Shokeir et al in our study also the resistive index did vary significantly with :

- age
- sex
- site of obstruction
- duration on obstruction

RI VALUE ACROSS AGE GROUPS :

Age	Mean resistive index	P value
<20 years	0.7100	Pvalue – 0.7083 > 0.05 not significant
21 – 30 years	0.7225	
31-40 years	0.7343	
>40 years	0.7325	

RI VALUE ACROSS THE SEXES

Sex	Mean resistive index	P value
Male	0.7289	0.146 not significant
female	0.7100	

RI AND THE SITE OF OBSTRUCTION :

Site of obstruction	Mean resistive index	P value
Proximal	0.7217	P value 0.9760
Middle	0.7271	Not significant
Distal	0.7289	

RI AND DURATION OF PAIN:

Duration on pain	Mean resistive index	P value
<24 hours	0.7215	P value 0.9705
24 – 48 hours	0.7400	Not significant
> 48 hours	0.7200	

It has been shown consistently in many animal models that acute obstruction consistently results in local , transient renal vasodilatation followed by vasoconstriction. The renal vasoconstriction is caused by several competing hormonal factors, the most important of which seems to be mediated by prostaglandin. It has been suggested that the renal vasoconstrictive response that occurs with cute obstruction is reliably identified by DU(42,53,54) .

IVU and grey scale US are the two most common imaging examinations used in patients with acute renal colic to determine whether obstruction is present.Examination with US is particularly useful in conditions when IVU is contraindicated, e.g. in pregnancy, a history of reaction to contrast material , renal impairment and repeated episodes of renal colic. However conventional US is an inaccurate test for obstruction, because dilatation of the collecting system is often seen in unobstructed kidneys and may not occur or may occur late in obstructed kidneys. Thus the present study aimed to determine the role of DU in the diagnosis of acute obstruction.

The role of DU in the evaluation of acute renal obstruction has been vigorously debated(42,53,54,62,63). Rodgers et.al., (53) found an elevated resistive index in acutely obstructed kidneys , especially when compared with

the resistive index in the normal contra lateral kidneys and with a control group of healthy subjects. Similar results are obtained by Platt et.al.,(47) in 23 patients with acute unilateral obstruction .however others reported that DU is highly insensitive for detecting acute renal colic (50.):Tublin et. Al. ,correlated the results of DU with those of urography in 32 patients presenting with renal colic. When the published discriminatory thresholds for obstruction (mean resistive index->0.70 and diff. resistive index> -0.10 were applied , the sensitivity and specificity of were only 44% and 82% only , respectively . this marked discrepancy in the results could be explained by the difference in the degree of obstruction. In a recent study , de Toledo et.al., (54) investigated the diagnostic accuracy of DU in complete as well as partial renal obstruction in 64 patients . with a threshold of >-0.70 and of diff. resistive index>-0.06 they showed a sensitivity of 92% in 37 patients with complete and 48% in 27 patients with partial obstruction .

The present high sensitivity for differential resistive index of 86% and specificity of 92% in diagnosing acute renal obstruction may have arisen because DU was carried out during the episode of renal colic and before giving any medication in most patients. Cronan and Tublin discussed

the effect of NSAID in the management of patients with acute renal colic. These drugs have been shown in animal models to reverse both the early vasodilatation and later vasoconstriction the occur with acute renal obstruction . Thus, their use may affect the expected changes in renal resistive index in previous studies, many patients had received NSAIDs before imaging. The effect of pharmacological agents on renal resistive index merits further study.

Previous investigators have shown that the increase in resistive index occurred after as little as six hours of clinical obstruction (47). This finding is supported by previous laboratory research that in the earliest stage of obstruction there is vasodilatation, with which the normal resistive index would be expected . However admission to hospital in the first five hours after onset of renal colic is uncommon. In such a situation, although the resistive index may not be high differential resistive index of more than 0.06 suggests unilateral obstruction before the resistive index reaches the 0.70 threshold. We were unable to investigate the shortest duration of acute renal obstruction that can cause elevation of resistive index as all the present patients presented with renal colic of more than 12 hours duration. In

patients with renal colic for less than 6 hours conflicting results have been obtained about the effect of duration of RI. We agree with Platt et al (47) that kidneys obstructed for more than 12 hours do not have a significantly higher resistive index than those with obstruction of shorter duration. On the other hand de Toledo et al (54) reported that the resistive index was significantly higher in patients with Renal colic for more than 24 hours. These differences would be attributable to the duration of obstruction based on the clinical history in all previous studies. The precise duration of obstruction in patients in a clinical series cannot be ascertained.

The most common reason for obtaining a normal resistive index in the presence of significant obstruction is a technical error that is simple to correct. As described previously the use of correct scale (pulse repetition frequency) to expand the wave form size to fill as much as the available display as possible without aliasing is crucial. With this strategy, errors in measurements of resistive index are reduced and flow at the end of diastole generally can be differentiated from background machine noise and wall filter.

The level of ureteric obstruction had no significant impact on the present values of resistive index in agreement with Platt et al (47). However, de Toledo et al (54) have shown that patients with proximal ureteric obstruction had RIs higher than those with distal obstruction.

Previous reports suggest that 17-29% of patient with the acute obstruction have abnormalities on DU despite normal grey scale US (47,53) ; such abnormalities were deducted in 35% of the patients. Therefore when US is used instead of IVU, Renal DU is necessary to improve the sensitivity in early obstruction and to provide functional information about an obstructed kidney (9).

Limitations of the present study :

1) There were no cases of acute bilateral obstruction or acute obstruction of a solitary kidney.
2) Another limitation (not found in the study) is patients with intermittent but very acute renal colic.
3) Another limitation is that resistive index could be elevated in conditions other than renal obstruction for e.g. : chronic hypertension and renal medical disease.

Therefore in the setting of known renal medical diseases and renal colic an elevated resistive index could be caused by the Renal Disease or obstruction thus limiting the value of an abnormal resistive index in this particular situation. The importance of differential resistive index in such condition is also unknown. However a normal resistive index in this setting would still be helpful in arguing against the presence of obstruction (66).

CONCLUSION :

In conclusion from the study it is evident that the resistive index measurement by Doppler ultrasound has a high sensitivity and specificity in detecting acute renal colic.

The sensitivity and specificity of resistive index in our study correlates with the finding of Platt et al, Shokeir et al , Malitec et al.

The most recent study conducted by Corderica et al also validates our findings .

As in previous studies inter-renal difference in resistive index is more sensitive and specific than resistive index and probably may play an important role in the diagnosis of obstruction in patients with medical renal

disease and in patients who present early when the resistive index is yet to increase.

RI measurements are not significantly influenced by age and sex in our patients who were in the age group of 20 -40 years.

Neither the site of obstruction nor the duration of obstruction significantly influenced the resistive index.

In conclusion resistive index measurement by doppler ultrasound is a sensitive and a highly specific test that can contribute significantly to the diagnosis and management of acute unilateral renal obstruction, particularly in situations in which IVU is undesirable or contraindicated as in pregnancy, contrast allergy or compromised renal function.

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PROFORMA :

NAME : AGE : SEX

CLINICAL HISTORY :

Description of pain

Duration of pain

- < 24 HOURS
- 24- 48 HOURS
- > 48 HOURS

Past history of calculous disease

History of diabetes/hypertension/tuberculosis

INVESTIGATIONS:

6. hemogram
7. urine RE
8. Urine c/s
9. blood urea, sugar, creatinine
10. Xray KUB

ULTRASOUND KUB: size of kidneys/ pelvicaliceal dilatation/grade of hydronephrosis

DOPPLER US: RI / DIFFERENTIAL RI

IVU: pelvicaliceal dilatation / site of obstruction.